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LOWER AND MIDDLE MISSISSIPPIAN
STRATIGRAPHY OF OHIO

A PART OF A DISSERTATION SUBMITTED TO
THE FACULTY OF THE DIVISION OF THE
PHYSICAL SCIENCES IN CANDIDACY FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF GEOLOGY AND PALEONTOLOGY

1941

By

FREDERICK T. HOLDEN

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ABSTRACT

The Lower and Middle Mississippian rocks of Ohio are briefly described. The principal stratigraphic problem is the subdivision of the Cuyahoga and Logan formations into facies and members. For these two formations some new member and facies names are proposed, and a possible explanation for the conditions of their deposition is suggested.

INTRODUCTION

The Lower and Middle Mississippian strata of Ohio consist of five formations, which are, in ascending order, the Bedford shale, the Berea sandstone, the Sunbury shale, the Cuyahoga formation, and the Logan formation. Most attention has been given to the problem of subdividing the Cuyahoga and Logan formations into a number of members and lithologic facies. Correlations between the various members of these two formations have been made partly by faunal evidence but more largely on the bases of stratigraphic position and succession. In this report some of the older classifications of the Cuyahoga and Logan formations have been modified and several new stratigraphic subdivisions have been proposed.

For the purpose of showing the areal distribution and regional structure of the Lower and Middle Mississippian formations in Ohio, a geological map with horizontal and vertical sections has been constructed. A table to indicate the general relationships of the various formations and their subdivisions is presented, together with index maps showing the geographic locations of the facies composing the Cuyahoga and Logan formations.

BEDFORD FORMATION

Resting on the Ohio shale of late Devonian age is the Bedford formation, named by Newberry from the excellent outcrops in the gorge of Tinkers Creek at Bedford, Cuyahoga County, Ohio. The Bedford consists essentially of argillaceous shales with a few

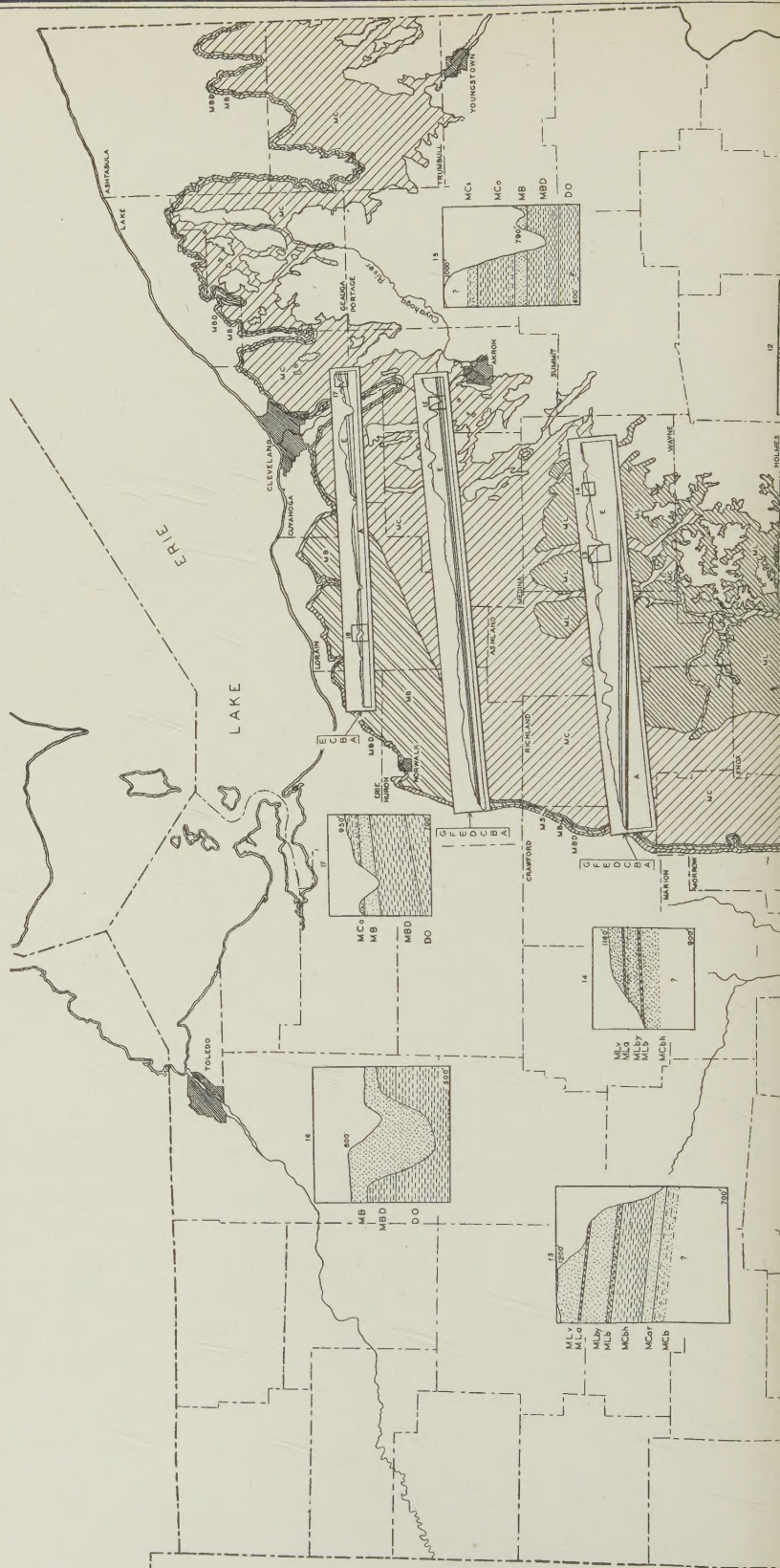
thin nonpersistent layers of sandstone. The outcrop area of the Bedford occupies a narrow zone in northern Ohio westward from the Ohio-Pennsylvania border to north-central Ohio and thence southward through the center of the state to the Ohio River.

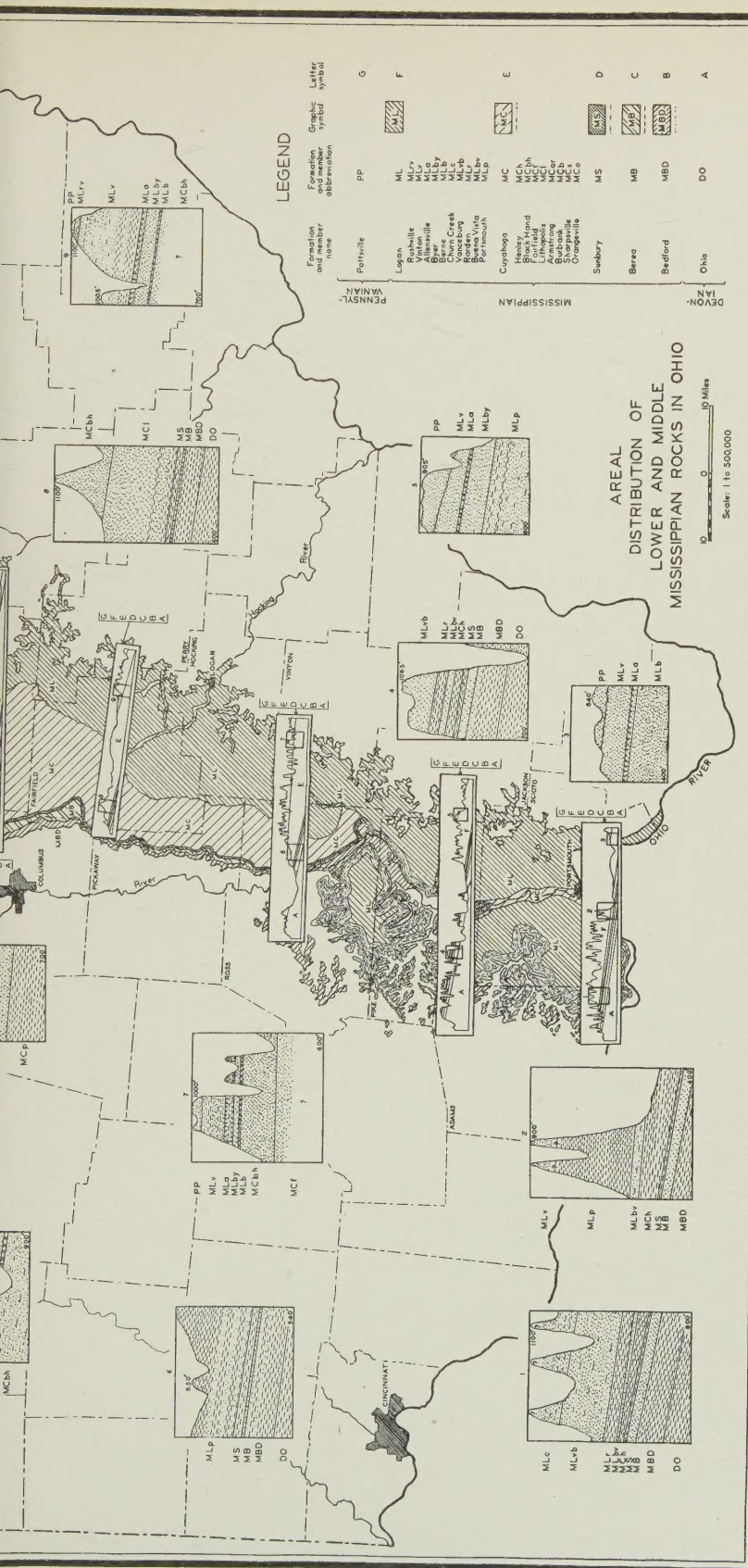
TABLE 1

GENERAL SECTION ON TINKERS CREEK AT BEDFORD, CUYAHOGA COUNTY		Feet	Inches
CUYAHOGA FORMATION			
Orangeville member:			
Blue and blue-black shale with some black streaks...	12		
Aurora submember:			
Blue-gray and gray, fine-grained sandstone layers alternating with blue-gray shale layers.....	8	3	
Blue-gray, thinly laminated, argillaceous shale, tending to split into very small fragments.....	5	8	
Black, very thinly laminated, fossiliferous shale.....	1		
BEREA FORMATION (altitude at base approximately 875 feet A.T.)			
Massive, gray to gray-buff, medium- and coarse-grained sandstone.....	22		
Thin, blue-gray, medium-grained sandstone with ripple marks.....	6		
Gray, medium-grained, massive sandstone.....	10		
BEDFORD FORMATION			
Blue-gray, sandy shales alternating with thin, fine-grained sandstones and siltstones.....	25		
Blue-gray, fine-grained sandstone and siltstone.....	22		
Blue-gray, argillaceous to arenaceous shales with thin lenses of siltstone.....	40		
OHIO SHALE (DEVONIAN)			

The Bedford shales throughout northern Ohio vary in color from one locality to another. In eastern Cuyahoga County the prevailing color is blue with some dark red or maroon, but farther west there is a general increase in the amount of red, although some sections have no red shale. Wherever exposed, the basal few feet of the Bedford are generally black, fissile, argillaceous shales.

The light blue-gray sandstone layers are composed of fine-grained sand and silt. Commonly from 3 to 12 inches thick, they are interbedded singly with shales. Most of the sandstone layers are ripple





marked. Locally they may thicken very considerably, as in the case of the Euclid lentil,¹ which is 20 feet thick in the vicinity of Cleveland, though areally of small extent.

From western Cuyahoga County west for some 40 miles into north-central Ohio the basal 5-15 feet of the Bedford are either black fissile shales or red argillaceous shales interbedded with thin, buff to gray, fine-grained sandstone, and overlain by 25-30 feet of blue, gray, or chocolate sandy shales containing a few thin layers of gray sandstones and gray limestones. This sequence is succeeded by 40-50 feet of chocolate and lavender argillaceous shales. No good exposures of the Bedford occur along the western outcrop zone of the Mississippian rocks in north-central Ohio, owing to the low relief and the cover of glacial drift.

The best exposures of the Bedford in central Ohio occur near Gahanna, Franklin County, where the formation consists of blue-gray, chocolate, and red shales through a vertical thickness of 90 feet.

In south-central Ohio the thickness of the Bedford varies from 80 to 110 feet. Generally in this region it displays at the base 10-20 feet of thin sandstones, sometimes interbedded with thin shale layers, overlain by 70-90 feet of chocolate, tan, and dark-gray shales (see the section in Table 8).

In many places in northern Ohio the basal portions of the Bedford have been structurally disturbed. Small folds are not uncommon, and locally they are complicated by thrust faults. No great thickness of the formation is involved, and neither underlying nor overlying beds are affected, indicating that the disturbance took place at or shortly after deposition of the materials.

Only a slight disconformity, marked largely by a sharp contact of contrasting shales, is present between the Bedford and the underlying Ohio shale. Fossils are found only in the basal 3-30 inches of the Bedford, where they are rather common.

BEREA FORMATION

Newberry gave the name "Berea sandstone" for outcrops at Berea, Cuyahoga County. The formation, occupying a narrow

¹ C. S. Prosser, "The Devonian and Mississippian Formations of Northeastern Ohio," *Ohio Geol. Surv.*, Bull. 15 (4th ser., 1912), p. 51.

outcrop zone, lies disconformably above the Bedford and is in turn overlain by the Sunbury shale from the Ohio River in south-central Ohio to Huron County in north-central Ohio and by the Cuyahoga formation from Huron County eastward to the Pennsylvania state line.

The Berea is a tan, light-gray or white, quartz sandstone, locally having a brown iron stain on weathered surfaces. Along the northern outcrop area in Ohio it is a fine-grained sandstone, but from Erie County southward there is a progressive decrease in grain size,² so that within 150 miles, at Waverly, it is a siltstone.

The thickness of the Berea varies considerably, especially in northern Ohio, where it was deposited on a surface of considerable relief. Where deep erosional channels were filled it exceeds 200 feet in thickness, while on interchannel areas it may be thin or entirely disappear within a few hundred yards of the deep channels. Thus a markedly disconformable contact occurs between the Berea and the underlying Bedford shale.

In central Ohio the Berea varies from 5 to 65 feet in thickness and in southern Ohio from 20 to 30 feet (see section in Table 8). The component beds in both central and southern Ohio are thin, ranging from less than an inch to 20 inches in thickness. Not uncommonly thin layers of gray shale appear at the base of the Berea in these portions of the state.

Characteristic of the Berea sandstone are abundant oscillation and current ripple marks which are very persistent in direction, the crests and troughs trending generally northwest-southeast throughout its outcrop area. They have been fully described by J. E. Hyde,³ who suggested that the uniformity in direction is because they formed parallel to the shoreline, the direction of the ripples giving the trend of the shoreline.

The Berea is essentially unfossiliferous, broken-shell fragments, fish and plant remains being found but rarely.

² F. Foreman and H. L. Thomsen, "Textural and Shape Variation in the Berea Sandstone of Ohio," *Jour. Sed. Pet.*, Vol. X (1940), pp. 47-57.

³ "The Ripples of the Bedford and Berea Formations of Central and Southern Ohio," *Jour. Geol.*, Vol. XIX (1911), pp. 257-70.

SUNBURY FORMATION

The black shales composing the Sunbury formation, which was named by L. E. Hicks in 1878 from outcrops near Sunbury, Delaware County, Ohio, lie beneath the Cuyahoga formation and above the Berea formation. The Sunbury is a black, fissile, thinly laminated, carbonaceous shale, commonly iron stained. The basal few inches contain numerous megascopic and microscopic fossils.

This shale crops out along the western margin of the Mississippian rocks exposed in Ohio, and by virtue of considerable topographic relief between Chillicothe, Ross County, and the Ohio River in southern Ohio the Sunbury outcrops can be traced for some 20 miles east from the western boundary of the Mississippian outcrops. Very few outcrops of the Sunbury occur north of southern Delaware County in central Ohio to Huron County because of the low topographic relief and the heavy cover of glacial drift. Throughout northeastern Ohio the Sunbury shale is not distinguishable from the overlying Orangeville shale member of the Cuyahoga formation. For this reason the Sunbury formation is not recognized east of Huron County, Ohio.

In central and southern Ohio the Sunbury formation varies in thickness from 15 to 30 feet. Along the Ohio River it is typically 15-20 feet thick.

CUYAHOGA FORMATION

J. S. Newberry proposed the name "Cuyahoga formation" in 1871. It includes a complex sequence of shales, sandstones, and conglomerates lying above the Sunbury shale and beneath the Logan formation. These reach a maximum thickness of slightly more than 300 feet. The Cuyahoga has been traced throughout the entire outcrop area of the Mississippian rocks of Ohio from Ashtabula and Trumbull counties on the northeast westward and southward to the Ohio River in Scioto and Adams counties.

The outstanding problem of the Cuyahoga is one of subdivision into facies and members. Each facies is a lithologic unit in which there is little or no textural change laterally. Also, owing to localized conditions of deposition, the sediments show a general uniformity in lithology vertically within a given facies. However, on the basis

of slight changes of composition, texture, or structure, the facies are subdivided vertically into lithologic members, which can be traced laterally over much or the whole extent of the facies. Only in the areas of transition from one facies to an adjacent one is there much change in lithology.

This type of subdivision of the Cuyahoga formation was suggested and begun by Hyde in 1915.⁴ The writer, while modifying some of Hyde's classifications, is continuing this system throughout the Cuyahoga in Ohio. Each facies at any one place includes the entire vertical thickness of the formation, whereas seven shale and conglomerate facies, in alternating geographic bands, comprise the outcrop area of the Cuyahoga formation (Fig. 2).

The Vanceburg facies occupies the southwesternmost part of the Cuyahoga outcrop area in Ohio in eastern Adams, Pike, western Scioto, and southern Ross counties. It includes in ascending order the following members: the Henley shale, Buena Vista sandstone, Rarden shale, Vanceburg sandstone, and Churn Creek member. The Scioto Valley shale facies, composed of the Henley shale, Buena Vista sandstone, and Portsmouth shale, crop out to the east along the Scioto River Valley in south-central Ohio.

In 1921, however, Hyde⁵ correlated the Buena Vista sandstone with the Berne member of the overlying Logan formation, thus including in the Logan formation the Buena Vista and all overlying members formerly in the Cuyahoga formation. The present writer agrees with this correlation; thus only the Henley member is considered to represent the Cuyahoga formation in both the Vanceburg and the Scioto Valley facies. Therefore, it is herein proposed to retain all the members defined by Hyde in 1915 in their respective facies, with the exception of the Henley member, and to include the Vanceburg and the Scioto Valley facies in the Logan formation instead of in the Cuyahoga formation. The Cuyahoga of this area, therefore, is limited to one facies only, the Henley shale facies, which consists of one member, the Henley shale. The lithology, paleon-

⁴ "Stratigraphy of the Waverly Formations of Central and Southern Ohio," *Jour. Geol.*, Vol. XXIII (1915), pp. 655-82, 757-79.

⁵ "Geology of Camp Sherman Quadrangle," *Ohio Geol. Surv.*, Bull. 23 (4th ser., 1921), pp. 49-90.

tology, and type localities of this and the following facies and members of the Cuyahoga and Logan formations will be treated at length later in this paper.

The Hocking Valley conglomerate facies as defined by Hyde in 1915 crops out northeast of the Henley shale facies outcrop (Fig. 2). Four members were here differentiated by Hyde: the basal Lithop-



FIG. 2.—Map showing the location of the facies of the Cuyahoga formation

olis member, the overlying Fairfield member, the Black Hand member, and the uppermost Berne member. In 1921 Hyde placed the Berne with the Logan formation. The basal and uppermost members of the Hocking Valley conglomerate facies are emended by the writer to "Lithopolis siltstone member" and "Black Hand conglomerate member," respectively.

The Granville shale facies of central and southern Licking County was described briefly in 1915 by Hyde, who distinguished the Raccoon member, the overlying Black Hand member, and the topmost Berne member. The latter, Hyde placed in the Logan formation in 1921. The present writer has traced this facies to the northwestward

into southwestern Richland and southeastern Crawford counties (Fig. 2). The two members of this facies are changed to the "Raccoon shale member" and the "Black Hand siltstone member," respectively.

The Toboso conglomerate facies as described in 1915 by Hyde is exposed in eastern Licking County. It consists of the upper Berne member, included in the Logan formation in 1921 by Hyde, the underlying Black Hand member, and a possible basal unnamed member. Field work by the present writer has extended the outcrop zone of the Toboso facies northwestward through eastern and northern Knox County into south-central Richland County. For the beds underlying the Black Hand member, which is emended to the "Black Hand conglomerate member," the writer proposes the new name, "Pleasant Valley member."

Northeast of the Toboso conglomerate facies outcrop, the Killbuck shale facies, heretofore unnamed, is exposed (Fig. 2). The members of this facies in ascending order are the Burbank, the Armstrong, and the Black Hand members, defined and described by G. W. Conrey in 1921.⁶ The designations of the latter two members are changed by the writer to "Armstrong sandstone member" and "Black Hand shale member," respectively.

In the eastern half of Wayne County and in southern Medina County there is exposed the newly named "River Styx" sandstone facies which consists of the Black Hand conglomerate member and the underlying Armstrong sandstone member. The latter includes the Rittman conglomerate submember first described by Conrey in 1921.

United States Geological Survey usage assigns to the Cuyahoga in northeastern Ohio the rank of group, subdivided into the three formations—the Orangeville, Sharpsville, and Meadville. Inconsistently enough, however, the Survey has given the Cuyahoga strata of Pennsylvania the rank of formation and its Orangeville, Sharpsville, and Meadville divisions each the rank of member.

All the Cuyahoga strata northeast of the River Styx facies outcrops are now included in the new Tinkers Creek facies, which is subdivided in ascending order into the Orangeville shale and the

⁶ "Geology of Wayne County," *Ohio Geol. Surv.*, Bull. 24 (4th ser., 1921), pp. 49-90

included Aurora submember, Sharpville sandstone, and Meadville shale members. The Tinkers Creek facies crops out in Ohio from Lorain and northern Medina counties to the Ohio-Pennsylvania boundary in southeastern Ashtabula and northeastern Trumbull counties (Fig. 2).

THE HENLEY SHALE FACIES

The Henley shale facies consists of but one member, the Henley shale, named by Hyde in 1915 from Henley, Scioto County. There is considerable variation in the thickness of this shale. It is thinnest along its western outcrop zone in western Scioto, Pike, Ross, and eastern Adams counties, and thickens northeastward from $5\frac{1}{2}$ feet to a maximum of 200 feet in east-central Pike County.

The Henley shale along its western outcrop zone consists of alternating red and gray argillaceous to silty, nonfossiliferous shales, but to the east, where it is thickest, the red color disappears. There is no evidence of a disconformity between it and the underlying Sunbury shale.

THE HOCKING VALLEY CONGLOMERATE FACIES

The Lithopolis sandstone member.—The Lithopolis member of the Hocking Valley conglomerate facies was named by Hyde in 1915 from outcrops near Lithopolis, Fairfield County. This member consists essentially of gray-blue, fine-grained, unevenly bedded sandstones interbedded with gray arenaceous shales. Weathered surfaces frequently are stained tan or brown. Inasmuch as its contact with the overlying member is everywhere covered, the maximum thickness of the Lithopolis can only be estimated to be between 180 and 200 feet. Exposures of the member are limited to northwestern Fairfield, southeastern Franklin, and southwestern Licking counties.

The Fairfield sandstone member.—The Fairfield member, which takes its name from outcrops in Fairfield County, overlies the Lithopolis and is exposed in Fairfield and Hocking counties. Thick coarse- and medium-grained sandstones alternating with shale layers, commonly of equal thickness with the sandstones, are distinctive of this member. The sandstones vary in color from gray to buff, tan, brown, and red-yellow; most commonly they are yellow-brown on both weathered and fresh surfaces. Each of these sandstone layers may be as much as 65 feet thick.

Because the Fairfield sandstones and fine conglomerates are similar in color and texture to the beds of the overlying Black Hand conglomerate member, the two members are easily confused, and their contact is difficult to recognize. The Fairfield sandstones not infrequently occur as thin-bedded, rather platy layers which break easily along joints into small blocks. It is the presence of the shales in the Fairfield member that distinguishes it from the Black Hand member in the Hocking Valley conglomerate facies.

The Black Hand conglomerate member.—The Black Hand conglomerate is the most widely exposed of any of the members in the Hocking Valley facies. It is typically a bright, varicolored, coarse sandstone or conglomerate, commonly cross-bedded, with rather steeply inclined laminae within beds. Some irregular, thin zones of coarse, white quartz pebbles occur imbedded in the main mass of the sandstone. The pebbles reach a maximum of 25 millimeters in length, are well rounded, and tend to assume a discoidal shape.

Over the center of the facies the most pronounced structural feature of the Black Hand is the persistent north or northeastward inclination of the lamination planes. The inclination is generally from 10° to 20° , with only the upper 10–20 feet of the member lying horizontal.

Along its western outcrop zone the Black Hand grades laterally into the shales of the Henley shale facies, but to the northeast its passage into the Granville shale facies is covered.

THE GRANVILLE SHALE FACIES

The Raccoon Shale member.—The Raccoon shale is nowhere well exposed, and its lateral and vertical extent are unknown. Generally it consists of blue-gray or brown, thinly bedded shale, sometimes stained a reddish-brown, containing thin, blue-gray and brown, fine-grained sandstone and siltstone lenses. Most of the Raccoon outcrops are along Raccoon Creek and Moots Run in central Licking County.

The Black Hand siltstone member.—The Black Hand siltstone is well exposed in the east-central part of the facies in eastern Granville and western Newark townships, Licking County. Elsewhere it is either lost by erosion or covered by glacial drift. A typical section is the one at the “Dugway.”

TABLE 3

SECTION AT THE "DUGWAY" ON OHIO HIGHWAY 16, 1½ MILES
WEST OF THE NEWARK CITY LIMITS

	Feet	Inches
LOGAN FORMATION		
Byer member:		
Tan-brown, thin-bedded, medium- to coarse-grained sandstone, beds 1-3 inches thick.	36	5
Berne member:		
Yellow-tan to brown, fine gravel conglomerate, becoming finer grained upward.	1	5
Yellow-tan, coarse, friable sandstone.	2	1
Red-brown to yellow, massively bedded, slightly fossiliferous sandstone. The lower 1 foot is a very coarse conglomerate of quartz pebbles. Near the top of the interval are thin, olive-tan, silty shales.	8	4
CUYAHOGA FORMATION		
Black Hand member (altitude at the base approximately 860 feet A.T.):		
Gray, fissile shale and thin layers of gray, brown, and tan siltstone.	2	5
Tan-gray, massive, cross-bedded, medium-grained sandstone.	3	6
Gray to tan, nodular, finely laminated shale and fine-grained sandstone weathering dark brown.	4	
Gray to brown, medium-grained, massive sandstone. .	8	5
Brown-gray, thin sandstone with gray, fissile shale layers.	12	2
Gray-tan, cross-bedded layer of sandstone weathering brown.	3	5
Gray-brown to red-brown, medium to coarse-grained, finely laminated sandstone with dark surface stain, each layer thin and changing rapidly in thickness laterally.	20	10
Light-gray, tan-brown and purple, fine-grained sandstone, somewhat cross-bedded and grading laterally into thin silty layers.	3	
Gray-green and gray-black, thin shales and thin brown, medium- to fine-grained sandstone layers interbedded. There is some carbonaceous matter in the sandstone.	7	7
Covered.	8	
Yellow-brown, thinly bedded, finely laminated, fine-grained sandstone. A few thin, gray shale layers. .	10	
Raccoon member:		
Blue-gray, thinly bedded shale weathering reddish-brown, containing a few gray, thin, sandy lenses and brown concretion lenses.	5	6

THE TOBOSO CONGLOMERATE FACIES

The Pleasant Valley member.—The Pleasant Valley member is named by the writer from exposures northwest of Pleasant Valley School on the north valley wall of a tributary of Clear Fork in SW. Sec. 5, T. 20 N., R. 19 W., Richland County. It is a gray-buff shale containing thin layers of medium-grained sandstone. In only a few places is the basal Pleasant Valley member exposed, and at such localities only the upper few feet are seen. About 15 feet of the

TABLE 4

SECTION IN SW. COR. SEC. 5, T. 20 N., R. 19 W.
RICHLAND COUNTY

	Feet
CUYAHOGA FORMATION	
Black Hand member (altitude at the base approximately 1,278 feet A.T.):	
White to yellow-brown, gray-brown, and dark-brown coarse, quartz sandstone, with a very few, very thin, gray, argillaceous shale layers. Bedding is generally rather thin.	
Some of the layers are friable.	36
Pleasant Valley member:	
Gray-buff shale with buff-gray, thin, medium-grained sandstone layers.	16
Gray-buff, medium-grained sandstone.	1
Gray-buff shale.	1

Pleasant Valley member are exposed along the south bank of the Licking River east of Newark, Licking County, where it consists of massive tan siltstones, grading to tan and gray arenaceous shale with lenses of medium-grained sandstone.

The Black Hand conglomerate member.—The Black Hand member is a massive, very resistant, highly cross-bedded conglomerate and coarse sandstone from 50 to 100 feet in thickness, containing numerous quartz pebbles $\frac{1}{4}$ – $\frac{1}{2}$ inch in diameter. The best exposures are at the type locality in the Black Hand gorge of the Licking River in Licking County.

The color of the Black Hand member is usually buff or yellow-brown, but at some places there are various shades of red and lavender. In northern Knox, southern Richland, and western Ashland

counties the member is a dark-brown to tan, coarse, friable sandstone.

The lamination planes in the upper 15 feet are nearly horizontal, but below they have a general inclination from 5° to 15° to the north and northwest on the southwestern side of the outcrop area, and from 10° to 15° north and northeastward on the eastern side of the Toboso facies.

THE KILLBUCK SHALE FACIES

The Burbank member.—The basal member of the facies is the Burbank, composed of a series of alternating gray arenaceous shales and buff-gray, fine-grained sandstones and siltstones with a maximum exposed thickness of 150 feet. Since the base of the member is not exposed, its total thickness is not known. The individual shale and sandstone layers rarely exceed 15 inches in thickness and generally are from 2 to 10 inches thick. The Burbank has been described in detailed sections by Conrey.⁷

The Armstrong sandstone member.—Above the Burbank member in the Killbuck facies is the Armstrong sandstone member, consisting of buff, gray-buff, and yellow-buff, fine-grained sandstone with a few interbedded, thin, gray shale layers. The lower sandstone layers are 1–2 feet thick, while the upper layers reach 3–8 inches. Typical sections may be measured in Killbuck Valley and Cedar Run Valley near Overton, Wayne County. The thickness of the Armstrong averages from 30 to 35 feet and reaches a maximum of 50 feet. It is difficult to determine the exact stratigraphic equivalent of the Armstrong member in the Toboso conglomerate facies, but it is probable that the Armstrong sandstone of the Killbuck facies is equivalent to the basal part of the Black Hand conglomerate of the Toboso facies.

The Black Hand shale member.—Overlying the Armstrong member in the Killbuck facies is the Black Hand shale, which has a total thickness of 75–80 feet. In this facies the Black Hand consists almost entirely of gray-blue shale, with sandstone layers only in the basal 10–20 feet. Generally very thin, the sandstones are fine grained and have a gray-brown color. The upper part of the member

⁷ *Ibid.*

may contain concretionary lenses 1-1½ inches thick. Exposures of the Black Hand in this facies are displayed in western Wayne County, since eastward the shales grade laterally into coarse sandstones

TABLE 5
SECTION IN CEDAR RUN VALLEY NORTHWEST OF
OVERTON, WAYNE COUNTY

	Feet	Inches
LOGAN FORMATION		
Byer member:		
Gray to brown, fine- and medium-grained sandstone. . .	50	
Berne member (altitude at the base approximately 1,015 feet A.T.):		
Brown, coarse sandstone containing fine gravel.	5	
Gray-brown, medium-grained sandstone.	10	
Dark brown, fine to coarse gravel conglomerate.	1	3
CUYAHOGA FORMATION		
Black Hand member:		
Gray and gray-blue arenaceous shale containing many concretionary lenses.	60	
Buff, fine-grained, massive sandstone.	4	
Gray-blue arenaceous shale with some thin sandstone layers.	6	
Armstrong member:		
Yellow-buff, medium-grained sandstone with a few layers of arenaceous, gray shale.	20	
Gray, medium-grained sandstones 1-2 feet thick with interbedded arenaceous shales 1-3 inches thick. . .	11	
Brown, medium-grained sandstone.	1	
Gray-buff, medium-grained, thin-bedded sandstone with thin shale partings.	4	
Gray-buff, massive, thick-bedded sandstone.	5	
Buff, fine-grained sandstone.	8	
Burbank member:		
Gray arenaceous shale and thin, brown and gray, medium-grained sandstone.	20	

and conglomerates of the Black Hand member of the River Styx facies.

THE RIVER STYX CONGLOMERATE FACIES

The Armstrong member.—The basal Armstrong sandstone member is not well exposed. It consists essentially of thinly bedded, gray to brown, fine- to medium-grained sandstones interbedded with

gray and red argillaceous shales. Within the Armstrong is a layer of about 2 feet of brown and tan, coarse conglomerate, which is fossiliferous and rather friable, overlying a dark olive, medium- and coarse-grained sandstone containing considerable mica. This sandstone and conglomerate compose the Rittman conglomerate submember, named by Conrey⁸ for exposures near the town of Rittman in northeastern Wayne County. The Rittman conglomerate is not traceable throughout the facies but has enough areal extent to merit ranking as a submember within the Armstrong.

The Black Hand sandstone member.—The Black Hand sandstone member crops out in the eastern part of Wayne County. Coarse, yellow sandstones with a few thin, gray shales constitute its upper 20 feet. Beneath are medium-grained, brown and gray sandstones and thicker shales. Detailed sections and descriptions have been given by Conrey.⁹

THE TINKERS CREEK SHALE FACIES

The Orangeville shale member.—The basal member in the Tinkers Creek facies is the Orangeville shale, named by I. C. White from outcrops at Orangeville, Trumbull County, on the Ohio-Pennsylvania boundary. This is a blue-gray to black shale containing very few sandstone lenses. Well exposed in Lorain and Cuyahoga counties, it is traceable from Lorain County eastward through the Mississippian outcrop zone into Pennsylvania. The basal portion of the Orangeville is equivalent to the Sunbury shale of central and southern Ohio, and the basal few inches, like the Sunbury shale, contain an abundance of small brachiopods, chiefly of the genera *Lingula* and *Orbiculoidea*. From 5 to 15 feet above the base of the Orangeville is a sandstone which is persistent throughout Cuyahoga County and the margins of surrounding counties. This is the Aurora submember, named the "Aurora sandstone member" by Prosser.¹⁰ It is a gray-blue, fine-grained sandstone or sandstones, with interbedded gray-blue shales in places. The thickness varies from $1\frac{1}{2}$ to $8\frac{1}{2}$ feet.

Above the Aurora submember are from 100 to 150 feet of gray to dark gray-blue soft, thinly laminated shale. The best exposures

⁸ *Ibid.*

⁹ *Ibid.*

¹⁰ *Op. cit.*, p. 211.

of this part of the Orangeville are found along Chippewa Creek west of Brecksville, Cuyahoga County.

The Sharpsville sandstone member.—The Sharpsville sandstone member was named by I. C. White from outcrops near Sharpsville, Mercer County, Pennsylvania. In the Tinkers Creek facies blue, fissile shales alternate with thin, blue to gray, fine-grained sandstones 1–3 inches thick and thinly laminated, gray, sandy shales, which in turn are overlain by alternating gray, thin sandstones and gray arenaceous shales containing poorly preserved fossils. With the fossils there may commonly be associated a considerable amount of marcasite and sphalerite. The thickness of the Sharpsville varies from 30 to 50 feet.

Separating the Sharpsville from the underlying Orangeville member, there may be a basal thin, gray-blue sandstone layer in the former member. Where such a sandstone layer is absent the underlying Orangeville merges gradually upward into the Sharpsville member. At the top of the Sharpsville the sandstones grade upward into gray, sandy shales of the Meadville member without a sharp boundary between the two.

The Meadville shale member.—The Meadville shale was named by I. C. White from exposures near Meadville, Crawford County, Pennsylvania. In the lower part of the Meadville blue-black, argillaceous, fissile shales and blue-gray, thin, laminated, arenaceous shales make up the bulk of the deposit. Some thin, blue-gray, micaceous, fine-grained sandstones are interbedded with the shales, and in addition there are numerous layers of blue, limy concretions some of which are fossiliferous.

The number and thickness of the sandstone layers increase in the upper portion of the Meadville until the sandstones make up as much of the deposit as the shales. Also in this part of the member are thin beds of blue-gray sandy limestone or calcareous sandstone weathering to a brown sandstone. The Meadville is much more fossiliferous than the underlying members of this facies.

Best exposed in Ohio in Cuyahoga and northeastern Medina counties, the thickness of the member increases from less than 100 feet in eastern Cuyahoga and northwestern Summit counties to over

200 feet in southwestern Cuyahoga and northeastern Medina counties.

LOGAN FORMATION

The Logan formation directly overlies the Cuyahoga formation and is in turn overlain in Ohio by the basal Pennsylvanian Pottsville formation except in the south-central portion of the state where, at a few places at the easternmost outcrops of the Mississippian, the Maxville limestone lies between the Logan and the Pottsville. Buff to gray, fine-grained sandstones, siltstones, and thin shales constitute the bulk of the Logan deposits, and laterally persistent thin beds of conglomerate serve as good horizon-markers.

From south-central Ohio the Logan extends northward with varying thickness to Holmes and Wayne counties, where it thins rapidly due to erosional beveling. In northeastern Wayne County and southern Medina County it pinches out entirely, and the Pennsylvanian rests directly upon the Cuyahoga formation.

Hyde in 1915 subdivided the Logan formation into three members: the Byer, Allensville, and Vinton, with the possibility of a fourth at the top, the Rushville member. In 1921 he changed the classification of the Berne from the top of the Cuyahoga to the base of the Logan formation. At the same time Hyde correlated several members previously included in the Scioto Valley and the Vanceburg facies of the Cuyahoga with the lower members of the Logan farther east. It is proposed in this work to subdivide the Logan into three facies, in a manner similar to the subdivision of the Cuyahoga. Both the Scioto Valley facies and the Vanceburg facies are moved, without change in their areal boundaries from the Cuyahoga formation into the Logan. In so doing, the Henley member is omitted from both the Scioto Valley and the Vanceburg facies, and the topmost Vinton member is added to each of these facies. The Scioto Valley shale facies is now subdivided into the following members: the Buena Vista sandstone at the base, the Portsmouth shale, and the Vinton sandstone; the Vanceburg siltstone facies of the Logan is subdivided into five members: the basal Buena Vista sandstone, the Rarden shale, the Vanceburg siltstone, the Churn Creek member, and the Vinton sandstone.

It is herein proposed to give the name "Pretty Run" to the facies of the Logan formation lying east of the Scioto Valley shale facies outcrop. The Pretty Run facies extends from eastern Scioto County north into Wayne and Medina counties (Fig. 3). Except where they have been removed by post-Mississippian erosion, there are ordinarily four members preserving the same lithologic characters through-

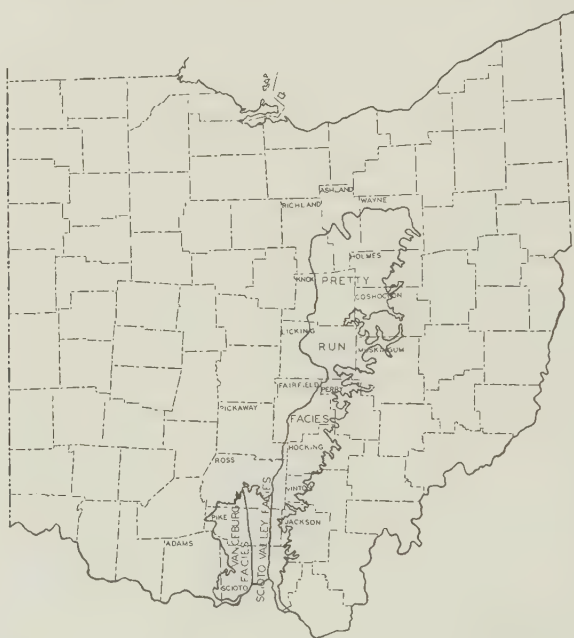


FIG. 3.—Map showing the location of the facies of the Logan formation

out the Pretty Run facies. These are the basal Berne conglomerate, Byer sandstone, Allensville conglomerate, and the Vinton sandstone, each defined and described by Hyde in 1915¹¹ and in 1921.¹² A fifth member, defined and described as the Rushville group by E. B. Andrews in 1878,¹³ is found above the Vinton sandstone in south-western Perry County, a few miles southeast of Rushville, Fairfield County.

¹¹ "Stratigraphy of the Waverly . . .," *op. cit.*, pp. 771-79.

¹² "Geology of Camp Sherman Quadrangle," *op. cit.*, pp. 145-58.

¹³ "Discovery of a New Group of Lower Carboniferous Rocks in Southeastern Ohio," *Amer. Jour. Sci.*, Vol. XVIII (3d ser., 1879), p. 137.

THE PRETTY RUN SANDSTONE FACIES

Outcrops typical of the Pretty Run facies of the Logan formation occur in east-central Eagle Township, Vinton County, near Pretty Run, from which this facies is named. The section was measured at the type locality (Table 6).

TABLE 6

SECTION IN SE. SEC. 22, NE. SEC. 26, AND NW. SEC. 25
T. 10 N., R. 19 W., VINTON COUNTY

	Feet	Inches
POTTSVILLE FORMATION (PENNSYLVANIAN)		
Coarse, white sandstone.....	15	
LOGAN FORMATION		
Vinton member:		
Sandy, gray, yellow-buff, and red shales with a few layers of buff, medium- to fine-grained sandstone..	55	
Allensville member:		
Fine gravel conglomerate.....	1	
Medium-grained, buff and brown sandstone with very thin lenses of conglomerate.....	13	10
Well-sorted, fine-gravel conglomerate.....	..	9
Byer member:		
Massively bedded, buff and brown, fine- and medium- grained sandstone tending to split horizontally into thin layers.....	84	9
Berne member (altitude at the base approximately 835 feet A.T.):		
Massive, coarse-grained, pebbly, yellow-brown con- glomerate.....	3	11
Medium-grained, brown sandstone.....	1	
Yellow-brown and gray coarse conglomerate.....	..	4
CUYAHOGA FORMATION		
Portsmouth member:		
Gray, slightly sandy shale.....	135	

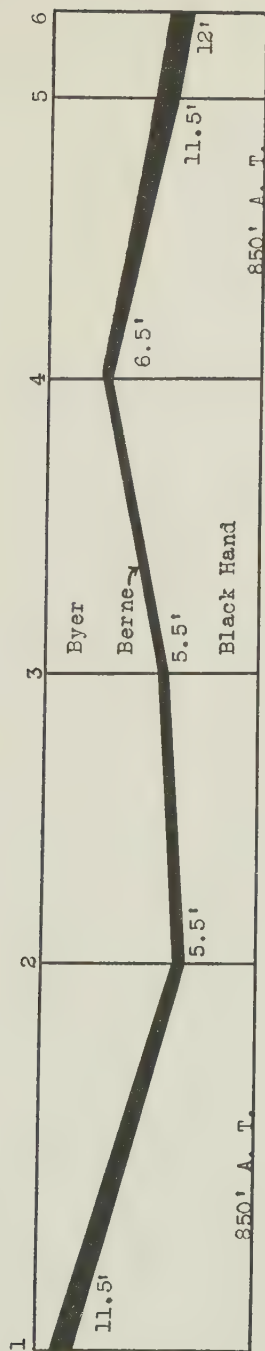
The Berne conglomerate member.—The Berne member of the Logan formation was named by Hyde from numerous outcrops in Berne Township, Fairfield County. In general, it is a basal conglomerate, composed of coarse quartz sand and quartz pebbles, well cemented with silica. Locally, fine- to medium-grained sandstone layers and shale layers are present. The thickness of the member varies from a few inches to 16 feet; commonly it is from 1 to 3 feet.

The Berne covers an uneven surface of the underlying Black Hand member. In tracing it across the area where it overlies the Toboso conglomerate facies of the Cuyahoga, the Berne is seen to rise in altitude and become thinner over the central part of the Toboso facies. Figure 4 represents a section with a constant thickness of 200 feet trending toward the southwest from Ashland County into Licking County. The shaded area represents the Berne conglomerate, between the Black Hand and the Byer members, showing its lateral variations in thickness and elevation with respect to the base of the section. As shown in this figure, along a line from Edlam, northeastern Knox County, into Licking County, the Berne rises in elevation from its position on the eastern margin of the Toboso conglomerate facies at Edlam to a maximum altitude in southern Knox County. From here it declines in altitude to the southwestern margin of the Toboso facies. Where the Berne overlies the adjoining Granville and Killbuck shale facies of the Cuyahoga there is an increase in its thickness. From Edlam north the Berne rises with regional inclination of 8 feet a mile.

Generally it can be shown that the thickest deposits of the Berne overlie the shale facies of the Cuyahoga, while it is thinnest where it overlies the conglomerate facies of the Cuyahoga. The overlying Byer, like the Berne, is thickest where it overlies areas of Cuyahoga shale deposition.

The thickness of the Berne and the Byer members where they overlie the shale facies of the Cuyahoga and their thinning where they overlie the Cuyahoga conglomerates suggest that at the time of their deposition the Cuyahoga conglomerate areas constituted topographic highs between the areas of Cuyahoga shale. Thus the sands and gravels of the Lower Logan members accumulated to a greater thickness in the low areas over the Cuyahoga shales. This relationship is somewhat complicated by the fact that in some places the uppermost Cuyahoga members of the conglomerate facies were beveled by erosion prior to initial Logan deposition.

The Byer sandstone member.—The Byer sandstone member is present throughout the Pretty Run sandstone facies. It varies considerably in thickness, measured sections showing a range from 18 to 154 feet. In general, however, there is little change in its litho-



KEY

1. SW. Sec. 34, T. 21 N., R. 15 W., Ashland County.
2. Edlam, Knox County.
3. NE. SE. Sec. 4, T. 6 N., R. 10 W., Knox County.
4. Sec. 8, T. 4 N., R. 11 W., Licking County.
5. Horn's Hill, northcentral Newark Township, Licking County.
6. "Dugway," southwestern Newark Township, Licking County.

The thickness of the Berne, which has been exaggerated, is designated at each locality.

Horizontal scale:
1 inch = 7 miles.

Vertical scale:
1 inch = 180 feet.

FIG. 4.—Vertical cross section showing variations in thickness and elevation of the Berne conglomerate across the Toboso conglomerate facies from Ashland County into Licking County, Ohio.

logic character. Buff to brown, fine- and medium-grained, rather thin-bedded sandstones prevail. Locally there are shale lenses of varying thicknesses, but there are no persistent distinctive lithologic units to relieve the monotony of the sandstone succession or to serve as key horizon-markers for the Byer throughout the Pretty Run facies.

Fossils are scattered and not abundant in the Byer sandstone. There are no fossiliferous horizons traceable over extensive areas, and in many areas the Byer is completely devoid of fossil remains.

The Allensville conglomerate member.—The Allensville conglomerate member was named and defined by Hyde from numerous outcrops in the vicinity of Allensville, Vinton County. It is characterized by well-sorted, coarse sand or fine-gravel conglomerate. The typical size of the well-rounded quartz grains ranges from 1 to 2.5 millimeters in diameter. The color of the grains may be white to colorless, or the grains may be stained varying shades of brown or red. The beds of well-sorted conglomerate each may be as much as 6 inches thick or may be but a thin veneer less than $\frac{1}{8}$ inch thick overlying finer-grained sandstone. Associated with the conglomerate beds are shales and beds of buff sandstone of varying grain size and thickness.

The Allensville is commonly from 15 to 20 feet thick, thinning to as little as 6 inches along the southwestern margin of its area of outcrop, and reaching a reported maximum of 39 feet in Pike County.¹⁴ It is a very persistent member and, as such, constitutes a valuable horizon-marker throughout the Pretty Run sandstone facies. From Hocking County to the northern limits of this facies the Allensville has approximately the same areal distribution as has the underlying Byer sandstone. The section (Table 7) displays a typical exposure of the Allensville in central Ohio.

Fossiliferous gray shale interbedded with the coarse sandstone and conglomerate layers is a typical association found in the Allensville from Fairfield County north into Ashland County. Stratigraphically the coarsest conglomerate beds occur most commonly at the top of the member. Geographically the coarsest material occurs in Wayne County, becoming finer in Licking and Knox counties and again

¹⁴ Hyde, "Stratigraphy of the Waverly . . .," *op. cit.*, p. 775.

coarser in southern Ohio. Everywhere the conglomerate beds have a high content of iron in the form of limonite, giving the matrix material a distinctive dark-brown color not seen in the Byer or Vinton members of the Logan formation.

TABLE 7

SECTION ON EAST SIDE OF ROCKY FORK IN SEC. 8, T. 4 N.
R. 11 W., LICKING COUNTY

	Feet	Inches
LOGAN FORMATION		
Vinton member:		
Buff, thin-bedded, medium-grained sandstone.....	49	
Gray to maroon, thin shales.....	10	
Allensville member:		
Yellow-brown, medium-grained sandstone.....	1	
Brown, medium-grained sandstone.....	5	
Brown, coarse-grained quartz sandstone.....	2	
Gray to buff somewhat sandy shale weathering red-brown to blue-brown, with interbedded buff, thin, medium-grained sandstone.....	4	
Red-brown to yellow-brown, well-sorted, coarse-grained, quartz sandstone, somewhat cross-bedded	5	
Byer member:		
Olive-buff, medium-grained sandstone, beds 6-12 inches thick. (A fossiliferous zone consisting mainly of crinoid stems occurs about 2 feet above the underlying shale. A few gray, argillaceous lenses and brown concretionary shale lenses are present).....	11	6
Gray, somewhat sandy shale.....	2	
Brown, medium-grained, cross-bedded sandstone, with a few layers of brown, fissile shale and lenses of gray, medium-grained sandstone.....	14	6
Berne member (altitude at the base approximately 990 feet A.T.):		
Coarse basal conglomerate grading upward within 3½ feet to coarse sandstone. (The upper 3 feet consist of a fairly well-sorted quartz conglomerate. Grains are 2-3 mm. in diameter, becoming coarsest at the top).....	6	6

Locally in Licking, Knox, and Wayne counties there is evidence of erosion at the base of and within the Allensville.

The Vinton sandstone member.—Comformably overlying the Allensville member in the Pretty Run sandstone facies is the Vinton sandstone member, named by Hyde from Vinton County,

where it is well exposed. The contact between the Vinton and the Allensville is always a sharp one, since the basal shale beds of the former lie directly upon the coarse sandstones and conglomerates of the latter without any gradation from the coarse to the fine deposits. This distinctive contact is persistent throughout the Pretty Run facies.

The Vinton consists largely of interbedded gray, arenaceous shales and gray to buff siltstones and fine-grained sandstones. The latter differ from those of the Byer in that they are generally gray when unweathered, whereas the Byer sandstone has a buff color. On weathered surfaces both the Byer and the Vinton sandstones are strikingly similar. A dark-yellow to yellow-brown highly fossiliferous layer, only a few inches thick and frequently used as a horizon-marker, can be found in the Vinton in many places throughout the Pretty Run facies.

The thickness of the Vinton varies considerably, owing to the fact that erosion beveled the Vinton, in places cutting rather deep valleys before Pottsville deposition began. Although its average thickness is 75-100 feet, the greatest reported thickness is 240 feet in southeastern Licking County.¹⁵

The Rushville shale member.—For about 0.2 mile along the road leading north from Avlon in the southwest corner of Sec. 36, T. 17 N., R. 17 W., Perry County, there are outcrops of shale, which probably correspond to the Rushville shale named and described by Andrews in this region in 1878. The Rushville member is a gray and red argillaceous shale containing a few buff, thin, sandy shale layers up to 2 inches thick. The base of the outcrop is at approximately 975 feet A.T., and coarse Pennsylvanian sandstone disconformably overlies the Rushville shale at about 1,000 feet A.T.

THE SCIOTO VALLEY SHALE FACIES

The Buena Vista sandstone member.—The Buena Vista member, first named by Orton in 1874, was defined by Hyde in 1915 to include the basal layer of the series known by quarrymen near Buena Vista, Scioto County, as the "City Ledge." Along the Scioto River Valley the Buena Vista reaches a maximum thickness of from 25 to

¹⁵ *Ibid.*, p. 779.

30 feet. It is a white to buff and gray, medium- and fine-grained sandstone with beds up to 16 inches thick interbedded with limonitic layers and arenaceous gray to buff shale.

East of the Scioto River the sandstones grade into sandy shales which become indistinguishable from the Henley shale and the Portsmouth shale. The eastward dip of the Buena Vista in the Scioto Valley facies is very slight, owing to the considerable eastward thickening of the underlying Henley member.

The northernmost outcrops of the Buena Vista occur in southwestern Ross County, where the thickness varies from 2 to 10 feet.

The Portsmouth shale member.—The Portsmouth shale overlies the Buena Vista sandstone in the Scioto Valley shale facies. At no place north of the Ohio River are there exposures of the Portsmouth shale where it is possible to measure its entire thickness. Only rarely are the contacts between the Portsmouth and the overlying and underlying members exposed.

The thickness of the Portsmouth shale where it crops out on the bluffs of the north bank of the Ohio River at Portsmouth, Scioto County, reaches a maximum of 253 feet. Here it is a gray argillaceous to silty shale containing a few sandstone lenses.

Inasmuch as (1) the thickness of the Portsmouth shale in south-central Scioto County exceeds the greatest known combined thicknesses of the Byer and Allensville members, and (2) because the base of the Portsmouth shale is at the same stratigraphic position as the base of the Byer, while (3) the base of the massive sandstone overlying the Portsmouth is considerably higher than the westward projection of the base of the Vinton, it seems probable that the upper part of the Portsmouth shale along the Ohio River is the westward equivalent of part of the Lower Vinton sandstone member of the adjacent Pretty Run facies. For convenience the base of the Vinton member in the Scioto Valley facies is set at the base of the sandstone overlying the Portsmouth shale.

In eastern Pike and Ross counties the Portsmouth shale grades eastwardly into the Byer sandstone member of the Pretty Run facies. The change from shale to sandstone is gradual, and the zone of transition is marked by a thick series of alternating buff arenaceous shales and shaly siltstones.

The Vinton sandstone member.—The Vinton sandstone member of the Scioto Valley facies consists of fine-grained sandstone and siltstone, massive to thin-bedded, buff to yellow-brown on weathered surfaces, and light buff to gray on fresh surfaces. It is found capping the higher hills on either side of the Scioto River Valley in Scioto and Pike counties. In northern Pike County and in Ross County, Pennsylvanian sediments disconformably overlie the Vinton east of the Scioto River. Throughout the facies the thickness of the Vinton is variable, since its upper limit is a very uneven erosional surface. From Ross County southward to the Ohio River the thickness varies from 135 feet to as little as 40 feet.

THE VANCEBURG SILTSTONE FACIES

The Buena Vista sandstone member.—The Buena Vista at its type locality near Buena Vista, Scioto County, has a thickness of $6\frac{1}{4}$ feet. Here it is composed of a basal layer of light-gray to white sandstone $2\frac{1}{4}$ feet thick overlain by 6 inches of shale and an upper sandstone layer $3\frac{1}{2}$ feet thick. Along its westernmost outcrop zone it varies from 1 to 6 feet in thickness. Where only 1 or 2 feet thick, it consists commonly of but one layer of light-gray siltstone and fine-grained sandstone. Eastward in this facies the Buena Vista thickens to a maximum of about 20 feet, as shown in the section (Table 8).

In western Jackson and Vinton counties the Berne conglomerate appears at the same horizon and in the same structural position as would the Buena Vista were the latter projected that far east with the dip which prevails in east-central Pike and Ross counties. Because of this possible equivalence of the Buena Vista with the basal Berne conglomerate, the Buena Vista is considered to be the basal member of the Logan formation in the Vanceburg and Scioto Valley facies.

The Rarden shale member.—Hyde named the Rarden member from the town of Rarden, Scioto County. It consists of red and gray argillaceous and silty shales with a variable thickness of from 25 to 30 feet. To the north and west of the outcrop area of the Vanceburg facies (Fig. 3) it has been removed by erosion, and east of the facies it grades into the gray Portsmouth shale.

The Vanceburg siltstone member.—The Vanceburg siltstone was named by Hyde from outcrops at Vanceburg, Kentucky. In general,

the Vanceburg member consists of fine-grained, buff to tan-brown sandstone and siltstone in layers 8-12 inches thick. Numerous thin, gray argillaceous shales are interbedded but make up only a small

TABLE 8
SECTION AT ELM GROVE, PIKE COUNTY

	Feet
LOGAN FORMATION	
Vanceburg member:	
Buff to tan-brown, fine-grained sandstone and siltstone in layers 8-15 inches thick, with intercalated gray, thin, argillaceous shales.....	59
Rarden member:	
Red and tan-gray argillaceous to arenaceous shale.....	31
Buena Vista member:	
White to gray-buff, medium- and fine-grained sandstone, beds up to 16 inches thick, with limonite lenses and gray and buff sandy shales.....	20
CUYAHOGA FORMATION	
Henley member:	
Olive-buff shale.....	25
SUNBURY FORMATION	
Black and brown-black fissile shale.....	15
BEREA FORMATION	
Gray-white, fine-grained sandstone and siltstone, beds 6 inches to 2 feet thick.....	26
BEDFORD FORMATION (altitude at base approximately 800 feet A.T.)	
Chocolate and olive-tan argillaceous to arenaceous shale...	74
Light buff, fine-grained, thinly-bedded sandstone.....	20
OHIO SHALE (DEVONIAN)	

percentage of the total bulk of the member. Its thickness varies from 80 to 150 feet, although no good exposures are available to show its entire thickness in the Vanceburg facies in Ohio. Furthermore, there is no dependable horizon at which to separate the Vanceburg from the overlying Churn Creek member, distinction between the two being made on the basis of the larger sandstone content of the former.

The Churn Creek member.—The Churn Creek member was named by Hyde "from Churn Creek in the southeastern part of Adams County on the divide between which and the head of Lower Twin Creek good outcrops are seen in roadside ditches."¹⁶ The Churn

¹⁶ *Ibid.*, p. 763.

Creek consists of a tan, gray, and reddish arenaceous to argillaceous shale, at some places with limy shale lenses. It may be as much as 100 feet thick, but very few exposures of the Churn Creek occur in the Vanceburg facies, so that its greatest thickness and areal extent cannot be exactly determined. Its presence has not been demonstrated anywhere except in eastern Adams and western Scioto counties.

The Vinton sandstone member.—The Vinton sandstone has been located in this facies only near Buena Vista, where it is a rather massive, yellow-buff, fine-grained sandstone. Its thickness is undetermined.

CONCLUSIONS

Taking into consideration that (1) the Tinkers Creek facies has a general southward dip of 15 feet a mile and that (2) the vertical distance between the top of the Berea formation and the top of the Cuyahoga formation in the River Styx and the Killbuck facies is from two to two and a half times the vertical distance between the same horizons directly north in the Tinkers Creek facies, it appears possible that the Tinkers Creek members are all stratigraphically below the exposed members of the River Styx and the Killbuck facies. The Black Hand member of the River Styx facies is the equivalent of the Black Hand members of each of the other facies to the southwest in the Cuyahoga formation. The Armstrong member of the River Styx and Killbuck facies is probably the equivalent of the basal part of the thick Black Hand member of the Toboso facies. The Burbank member of the Killbuck facies, the Pleasant Valley member of the Toboso facies, the Raccoon member of the Granville facies, and the Fairfield member of the Hocking Valley facies may all be equivalents. The Lithopolis member of the Hocking Valley facies is similar in lithology as well as in stratigraphic position to the upper members of the Tinkers Creek facies. It may be equivalent to part or all of the combined Sharpsville and Meadville members. These correlations are made primarily on the basis of stratigraphic position and structure, since the fossil content of many of the various members is too scanty and poorly preserved for reliable correlation.

The axes of each of the conglomerate facies, i.e., the Hocking Valley, Toboso, and River Styx facies, have a general north-northwest—

south-southeast trend, which is in contrast to the more nearly north-east-southwest trend of the Mississippian outcrops in Ohio. Without exception the conglomerate facies are thicker than the shale facies. Of particular structural importance is the fact that except in the uppermost few feet the lamination planes in each of the conglomerate facies dip northeast 10° – 30° on the northeast and east flanks of the facies. The dip of the laminae on the west flanks of the facies is west to northwest 5° – 15° and north and northwest 5° – 10° along the axial portion of each of the conglomerate facies. The topmost beds are essentially horizontal. The westward dips are less in degree than the eastward dips, owing to regional tilting to the eastward.

Each conglomerate facies becomes narrower in lateral extent in progressing northwestward, whereas each shale facies is wider in that direction (Fig. 2). This, together with the fact that the conglomerates become finer grained to the northwest and dip west, northwest, north, and east, suggests that the material was derived from lands to the southeast.

It is apparent that any strong shore current or wave action would have spread the gravel and sand deposits alongshore laterally from the long axes of the facies. Thus the conglomerate facies would not have formed the existing distinct bodies which are fairly sharply defined from the shale facies. This condition and the presence of abundant irregular cut-and-fill type of cross-bedding in the conglomerates and sandstones suggests deposition under the influence of strong currents at or near river mouths. Protected areas of rather deep water must have obtained where the most steeply dipping, laminated conglomerates were deposited. Where cross-bedding is of only a few inches in magnitude or is absent, it is probable that the sediments were deposited under the influence of shore and wave currents with stream currents relatively unimportant.

Were it not for the fact that only marine fossils are present in these conglomerates, they doubtless would be regarded as essentially nonmarine. A possible explanation of these puzzling Cuyahoga sediments is that they are delta deposits laid down in marine waters, cross-bedded by the continuation of river currents into a shallow sea, and not greatly influenced by wave action or shore currents. Such coarse materials could be deposited in deltas by streams of consider-

able volume, steep gradient, and relatively short courses. Evidence seems to indicate that all the Cuyahoga conglomerate facies were deposited simultaneously and parallel to each other.

The shale facies which alternate laterally with the conglomerate facies represent areas of accumulation of fine sands, silts, and clays. These facies appear from their fossil content to be marine, and they are not so thick as the conglomerate facies.

As stated in the discussion of the Henley facies, the Henley shale is the only member in this facies and represents the extent of deposition in this area during all or part of Cuyahoga time. The westward thinning of the Henley may mean that the Cincinnati arch was a topographic feature of some importance when the Henley was deposited.

No axial trend for the Pretty Run facies of the Logan formation can be determined (Fig. 3), since most of the northern and all of the eastern and southern boundaries are covered. The Scioto Valley shale facies has a long axis trending north-south. To its west the Vanceburg siltstone facies is elongate north and south, but the western margin of this facies has been lost by erosion.

The relatively widespread areal extent of the Pretty Run facies, together with the fact that there are no important lithologic changes laterally in any of its members, whereas vertically there are conspicuous contrasts in lithology, suggests that from time to time in the Pretty Run episode there was considerable change in the types of sediment being deposited in a sea in which wave action and currents sorted the materials and spread them out rather broadly.

Disconformably overlying the Cuyahoga formation, the Berne conglomerate of the Logan formation is a basal conglomerate representing coarse materials from rejuvenated erosion of adjacent lands. The Berne is somewhat thicker over the shale facies of the Cuyahoga, i.e., the areas of lesser amounts of Cuyahoga deposition, than over the conglomerate facies. The fact that the Berne, as well as the higher Allensville conglomerate, thins and disappears along the western margin of the facies in south-central Ohio indicates that the source of the materials for these and the other members of the Pretty Run facies was to the east or southeast. The deposits of the Scioto Valley and the Vanceburg facies probably came from the

south. There is no evidence of land areas to the north or to the west, and it is very likely that the sediments of Logan formation came from the same lands that supplied the material of the Cuyahoga formation.

Regionally all the Mississippian formations in Ohio dip from the Cincinnati arch in western Ohio eastward into the portion of the Appalachian trough lying west of the folded belt in Pennsylvania and West Virginia. The axis of the trough pitches to the south-southwest. Therefore, the east-southeast dips of the formations into the trough decrease from south to north along the east flank of the arch. In southern Ohio the eastward dip varies from 20 to 25 feet a mile; in central Ohio it is from 15 to 20 feet a mile. The true south-east dip of the Mississippian formations in southern and central Ohio is somewhat obscured by the eastward thickening of these formations. Across the northeastern part of Ohio the formations are essentially horizontal. Locally in Cuyahoga County there is a slight westward dip. The southward component of the southeastern dip of the strata ranges from 10 to 15 feet per mile along the eastern margin of the Mississippian outcrop zone in Ohio.

Since fossils are relatively scarce in the Mississippian rocks of Ohio and little study has been given to the faunas that have been found, correlation of these rocks with other Mississippian formations is not exact. The fossils of the Bedford formation suggest both Devonian and Mississippian affinities. In Kentucky the Bedford together with the underlying Devonian Ohio shale and the overlying Berea and Sunbury formations merge into the Chattanooga shale. Fossils of the Sunbury shale indicate its Kinderhook age. The Cuyahoga formation appears to be equivalent in age to the Fern Glen and the Burlington formations in the Mississippi River Valley. The Logan formation is the Ohio equivalent of the Keokuk (late medial Mississippian) of the Upper Mississippi Valley region.

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